MEGASPORE ASSEMBLAGES FROM VISÉAN DEPOSITS AT DUNBAR, EAST LOTHIAN, SCOTLAND

by EDWIN SPINNER

ABSTRACT. Megaspore assemblages are described from two coal seams in the lower Limestone Group. Two new species are proposed; *Setosisporites pseudoreticulatus* and *Zonalesporites fusinatus*. The genera *Lagenicula* (Bennie and Kidston) Potonié and Kremp 1954 and *Setosisporites* (Ibrahim) Potonié and Kremp 1954 are emended. Two new combinations are proposed: *Setosisporites indianensis* (Chaloner), and *Setosisporites splendidus* (Zerndt). The assemblages are compared with published records of megaspores from North America and Europe.

DUNBAR, East Lothian, is situated on the east coast of southern Scotland, some 25 miles east of Edinburgh. Exposed on the foreshore approximately 2 miles east of the town centre near the Barns Ness lighthouse are a group of alternating limestones, shales and sandstones, the prominent members of which are named as follows (from a detailed succession given by Lumsden, in press):

Upper Skateraw Limestone	↑
shales etc.	
Middle Skateraw Limestone	
Skateraw Coal	
shales, sandstones etc.	
Lower Skateraw Limestone	25 metres
shales etc.	
Upper Longcraig Limestone	
shales etc.	
Longcraig Coal	
Middle Longcraig Limestone	↓

Of two thin coal seams, approximately 10–22 cm. thick, the lower, named here Longcraig Coal, can be seen at the base of a low ridge (high-water mark) formed by the overlying Upper Longcraig Limestone (NT 7155 7730). The upper seam, named here Skateraw Coal, occurs 5–6 m. above the Longcraig seam in the succession and crops out on a small promontory 200 m. farther east towards the lighthouse. Both localities are clearly indicated on the geological map permanently exhibited on a wall in the derelict limestone kiln situated just above the shoreline as well as by marker pegs on the ground.

This succession is locally assigned to the Lower Limestone Group of the Carboniferous Limestone and is probably upper P_1 or basal P_2 age (pers. comm. Dr. R. B. Wilson, Institute of Geological Sciences, Edinburgh, based on the tentative correlation of the Upper Longcraig Limestone with the Hurlet Limestone of the Glasgow area; see also Currie 1954, p. 533). By its geographical position, this succession probably represents part of a link between the depositional areas of the Midland Valley of Scotland, and the Northumberland Trough of England in Upper Viséan–Namurian time.

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The succession was brought to the writer's attention by Dr. R. H. Wagner as a result of a field excursion, led by A. Davies and D. C. Greig (Institute of Geological Sciences) and subsequent discussion of the stratigraphic age of the strata.

Although the work began as a study of the presence, preservation, and variety of megaspores in this deposit and of the possibilities of changes in megaspore assemblages as an aid in the subdivision and correlation of Viséan deposits in this area, it was found during the work that some revision of the systematic descriptions was desirable, and that some new taxa were necessary. A comparative account is also given of published records of megaspore assemblages from deposits of Lower Carboniferous age in other areas.

Channel samples were taken of both seams and megaspores were obtained by using Schulze's solution (2 days) followed by repeated washings with 5% Potassium hydroxide solution. Specimens were prepared for both transmitted and reflected light examination.

SYSTEMATIC DESCRIPTIONS

No suprageneric classification is employed, and the arrangement is in alphabetical order. The type material is deposited in the reference collections, Microplaeontology Laboratory, Geology Department, University of Sheffield, England.

Genus LAGENICULA (Bennie and Kidston) Potonié and Kremp emend.

1954 *Lagenoisporites* Potonié and Kremp, p. 152.
1962 *Rostratispora* Bharadwaj and Venkatachala, p. 25.

Type species. Lagenicula horrida Zerndt 1934.

Emended diagnosis. Trilete megaspores with an apical prominence formed by the progressive expansion of the laesurae along most of their length from the junction with the curvaturae to the proximal pole, and the thickening of the exine of the greater part of the contact areas.

Description. This expansion often, but not necessarily, results in a longer polar than equatorial axis of the spore body. There is a tendency for lateral compression to be most common, but polar oblique compressions are found. Spores compressed laterally are bottle-shaped in outline, polar compressions circular to oval in outline. Originally the spore body was more or less spherical in shape. Contact areas are usually distinct, laevigate or ornamented with elements, similar in form to but smaller in size than those which characterize the distal surface. Exine ornamentation is varied consisting of basic elements e.g. verrucae, cones, spines, pilae, baculae, capillae 'hair-like' forms, or more complex elements with features of two or more of the basic type, or the exine may be laevigate. Often two layers of exine can be distinguished (transmitted light) the inner layer when distinguishable being thin and often folded.

Comparison and remarks. Lagenicula is most similar to *Setosisporites* (Ibrahim). However, in *Setosisporites* the apical prominence is formed mainly by the expansion of the laesurae, which generally occurs only in the area immediate to the proximal pole. Also, the heightening of the laesurae is relatively abrupt in *Setosisporites*, not a gradual increase towards the proximal pole as in *Lagenicula*.

Setispora Butterworth and Spinner 1967 may appear similar to *Lagenicula*, particularly in 'dry' specimens. However, any indication of an apical prominence in *Setispora* is due to sculptural elements on the laesurae.

Some specimens of *Cystosporites* Schopf 1938 may have an apical prominence similar to *Lagenicula* (e.g. see Chaloner 1954), but the extremely long polar axis and mesh-like structure of the sac-like spore body clearly distinguish the genus. Isolated abortive specimens of *Cytosporites* may be confused with small laevigate specimens of *Lagenicula*, e.g. *L. nuda* Nowak and Zerndt 1936.

Lagenoisporites Potonié and Kremp 1954 and *Rostratispora* Bharadwaj and Venkatachala 1962 are characterized by an apical prominence essentially similar to that of *Lagenicula*. The former genus was separated by its authors from *Lagenicula* on the presence of a more or less smooth or laevigate exine. *Rostratispora* was proposed on the basis of a verrucose rather than 'hair-like' sculptural elements on the exine. Opinion varies considerably on the use of differences in ornamentation to group otherwise similar specimens at a generic level, but I doubt the value of further subdivision at this level on the basis of differences in ornament. Many lageniculate forms are known with very fine elements which are difficult to see on dry specimens. Others when examined by transmitted light reveal elements which vary considerably in form and are difficult to describe in terms of basic element types such as cones, verrucae, pila.

It is proposed that the close similarity in form of apical prominence and original shape of body, suggests that the older name *Lagenicula* should be retained for the genus, with *Lagenoisporites* and *Rostratispora* as junior synonyms; and that the ornament differences are used at a specific level.

Botanical affinities. Lepidodendraceae; Potonié 1962.

Lagenicula subpilosa (Ibrahim) forma *major* Dijkstra ex Chaloner 1954

Plate 84, figs. 1–4

1950 *Triletes subpilosus* forma *major* Dijkstra, p. 871 (nom. nud.).
1954 *Triletes subpilosus* forma *major* Chaloner, p. 27, pl. 1, figs. 4–8.
?1957 *Triletes subpilosus* (Ibrahim) S.W. et B. forma *major*; type 271*b* Dijkstra, p. 14, pl. 9, figs. 94–6, pl. 10, figs. 97–103.
?1957 *Triletes subpilosus* (Wicher) S.W. et B. forma *major* Dijkstra; Dijkstra and Piérart, pp. 12–13, pl. 11, figs. 126–7.
1959 *Triletes subpilosus* forma *major* (Dijkstra) ex Chaloner; Winslow, pp. 18–20, pl. 1, figs. 1–9.
?1962 *Lagenicula subpilosa* (Ibrahim) Potonié and Kremp; Ishchenko and Semenova, *pars* p. 71, pl. 8, fig. 1.
1967 *Lagenicula subpilosa* (Ibrahim) forma *major* Dijkstra ex Chaloner 1954; Butterworth and Spinner, pp. 13–14, pl. 3, figs. 2–4.
?1967 *Lagenicula subpilosa* (Ibrahim 1933) Potonié and Kremp 1955 *pars*; Karczewska, pp. 286–7, pl. 2, figs. 4–6.

Description. See Chaloner 1954, p. 27; Winslow 1959, pp. 18–20; Butterworth and Spinner 1967, pp. 13–14.

Remarks. The material assigned here to this *forma* agrees closely with an earlier description (Butterworth and Spinner 1967, pp. 18–20), but an additional feature noted on several specimens is the presence of a thin, folded layer of exine within the ornamented layer that is generally regarded as the spore wall.

Since there is some disagreement over the value of recognising this *forma* (Karczewska 1967, p. 286), and also in the variation in over-all size of spores, length of sculptural elements etc., which appear to vary with stratigraphic horizon (Winslow 1959, pp. 18–20), the following new results are recorded: Maximum diameter of the spore 960–1760 μ, mean 1280 μ, based on 50 specimens mounted in a hydrous medium; One other specimen measured 640 μ in maximum diameter. The apical prominence ranged between 150 and 300 μ in height, 200–400 μ in basal width (height measured on lateral compressions as from beginning of projection from curved spore outline to apex). The spines on the outer layer of exine, distal to the curvaturae, varied between 80 and 250 μ in length, 16–40 μ in basal diameter, 4–10 μ in diameter at the apex or tip.

These figures are in approximate agreement with those previously recorded by Winslow (1959, p. 18) from the Hardinsburg Formation, Kentucky, U.S.A. (low Chester Series, Mississippi) and by Butterworth and Spinner (1967, p. 14) from the Bernician beds, Cementstones, Cumberland, England (Viséan S_2). Dijkstra (1952, p. 103) in describing this *forma* for the first time gave a size range of 500–1300 μ, mean 866 μ, based on 50 'dry' specimens.

The species *Lagenicula subpilosa* (Ibrahim) Potonié and Kremp 1955, which characterizes strata of low Westphalian age, has a similar size range (320–1100 μ, mean 652 μ, Dijkstra 1946, p. 46 and 1952*a*, p. 103, 'dry' specimens; 550–1270 μ, Winslow 1959, p. 17, wet specimens) to *L. subpilosa* forma *major*. This led Karczewska (1967, p. 286) to reject the forma. However, as Winslow pointed out (p. 18) the distal spines on *L. subpilosa* are generally less than 100 μ in length, and the maximum length of the spines recorded by Karczewska is 115 μ. It is therefore suggested that on the basis of larger mean diameter of spore, length of spines and different stratigraphic age, that the retention on this forma is of value.

The relatively short dimensions of the spines, as given by Karczewska, makes the inclusion of her record in the synonymy questionable. Also Dijkstra (1957, p. 14), Dijkstra and Piérart (1957, p. 13) describe short elements 10 μ long between the larger distal spines. These were not reported by Winslow (1959) or by the author, either in 1967 (Butterworth and Spinner) or during the present study.

Affinities. Lepidodendraceae; Potonié and Kremp 1954.

Stratigraphic distribution. Europe: Turkey, Namurian ABC (Dijkstra 1952); Ireland, Lower Carboniferous (Dijkstra 1957, Chaloner 1966); Scotland, Dinantian-Namurian (Chaloner 1954, ?Dijkstra 1957, Sen 1964); England, Viséan (Butterworth and Spinner 1967); ? Moscow Basin, Lower Carboniferous

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EXPLANATION OF PLATE 84

All specimens by transmitted light.

Figs. 1–4. *Lagenicula subpilosa* (Ibrahim) forma *major* Dijkstra ex Chaloner 1954. 1, Proximal surface, polar compression, ×100; slide D/10. 2, Lateral compression, ×50; slide D/11. 3, Part of specimen to illustrate cones on contact areas, ×100; slide D/12. 4. Part of specimen illustrating spines projecting from distal surface, ×100; slide D/13.

Figs. 5–7. *Setosisporites pseudoreticulatus* sp. nov. 5. Proximal surface, polar compression, ×100; slide D/7. 6, Holotype, oblique compression, ×100; slide D/8. 7, Lateral compression. ×100, slide D/9.

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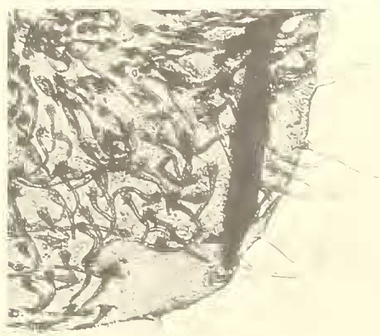

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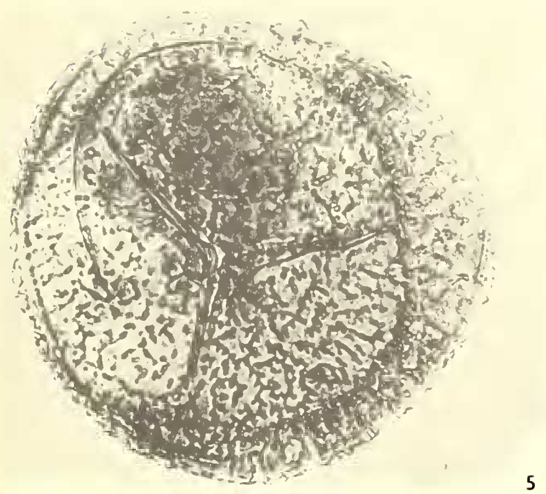

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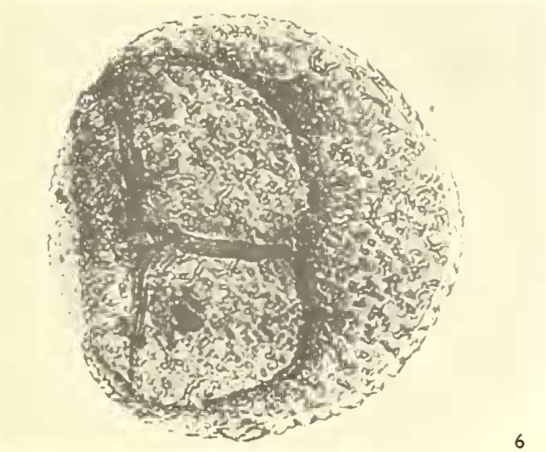

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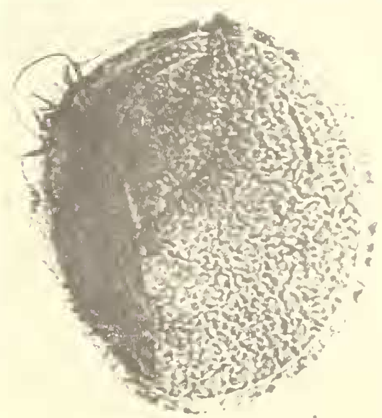

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SPINNER, Scottish Viséan megaspores

(Dijkstra and Piérart 1957); ? Poland, Viséan (Karczewska 1967). U.S.A.: Illinois, Indiana, Kentucky, Michigan, Mississippian (Chaloner 1954, Winslow 1959).

Genus SETOSISPORITES (Ibrahim) Potonié and Kremp 1954 emend.

Type species. Setosisporites hirsutus (Loose 1932) Ibrahim 1933.

Emended diagnosis. Trilete megaspores characterised by an apical prominence at the proximal pole, formed mainly by the expansion of the laesurae at the pole, although the polar part of the contact area may be involved. The greater parts of the contact areas are not involved in the formation of the apical prominence whose size relative to the spore body is such that the polar and equatorial axes are of similar dimensions. There is no preferred type of compression; polar oblique compressions are circular to oval in outline, lateral compressions bottle-shaped. The spore was originally more or less spherical in shape. Distal to the apical prominence the laesurae are low and of variable length. Contact areas are distinct, laevigate, or ornamented with elements similar to those present on the distal surface, but smaller in size. Spore wall when ornamented is covered with basic grana, cones, spines baculae, capillae or pilae type elements of variable size and density.

Comparison. In their original diagnosis of this genus Potonié and Kremp (1954, p. 152) referred to the exine ornamentation, except the contact areas, as being branched, slightly pointed, short or also relatively long hairs. The emended diagnosis refers to the original shape of the spore body, form of apical prominence and wide variation in exine ornamentation. See also under emendation of *Lagenicula* above.

Botanical affinities. Porostrobus spp. (Chaloner 1958, Bharadwaj 1958); *Bothrodendrostrobus watsoni* (Chaloner 1967).

Setosisporites indianensis (Chaloner 1954) comb. nov.

Plate 85, figs. 1–4

1954 *Triletes indianensis* Chaloner, p. 28, pl. 2 figs. 1–2.
1959 *Triletes indianensis*; Winslow, p. 26, pl. 6 figs. 1–3.

Size and shape. Trilete megaspores circular to oval in outline varying between 875 and 1615 μ in max. diameter, mean 1195 μ (based on 28 dry specimens). Polar, oblique and lateral compressions are found. Lateral compressions are bottle-shaped due to the projection of an apical prominence. However, the polar axis of the compressed spore is not always larger than the equatorial axis. Originally, the spore body was more or less spherical in shape.

Haptotypic features. An apical prominence is present at the proximal pole. Bluntly pyramidal in shape, this structure is formed by the expansion of the contact areas close to the proximal pole, and in part (?) by the laesurae. Basal diameter of apical prominence varies 200–375 μ, 50–150 μ in height. The laesurae extend as low trilete ridges from the apical prominence to the curvaturae, 30–60 μ high and wide. On the apical prominences of some specimens small ridges occur as (?) extensions of the laesurae.

Contact areas occupy approximately three-quarters of the proximal surface of the compressed spore and ornamented with small grana approximately 6 μ in diameter. The position of the curvaturae are marked by low arcuate ridges which are only well developed at the junction with the laesurae, 25–50 μ wide, approximately 25 μ high.

Exine structure and sculpture. The spore wall, distal to the contact faces is ornamented with densely placed granulate to conate type elements 10–15 μ up to 20 μ in basal diameter and height. These are generally more densely placed in the region of the curvaturae. Internal to the granular layer, a thin membrane can be seen on broken specimens. The outer granular layer of exine varies 30–50 μ in thickness.

Comparisons and remarks. Chaloner 1954 and Winslow 1959 both assigned this species to *Triletes*, sensu Schopf, Wilson, and Bentall 1944. An attempt to place this species in one of the narrower genera proposed by Potonié and Kremp 1954, encounters difficulties.

These authors proposed three genera of lageniculate megaspores i.e. *Lagenicula* (Bennie and Kidston) emend., *Lagenoisporites* Potonié and Kremp and *Setosisporites* (Ibrahim) emend. The primary feature used in distinguishing these genera being the structure, form and size of the apical prominence relative to the spore body, and a secondary feature being the type of (or lack of) ornament on the exine. In type of apical prominence *T. indianensis* is more similar to *Setosisporites* e.g. *S. praetextus* (Zerndt) Potonié and Kremp 1955, than *Lagenicula* e.g. *L. horrida* (Zerndt) Potonié and Kremp 1954. However, the exine ornamentation in *Setosisporites* is 'hair-like' e.g. *S. hirsutus* (Loose) Ibrahim 1932. Comparing with *Lagenoisporites T. indianensis* is similar in the small differences in length, between polar and equatorial axes, and in the small size of sculptural elements on some specimens which give an approximately smooth appearance, particularly on specimens not well preserved. The apical prominence in *Lagenoisporites* is, however, formed by the expansion along most of the length of the laesurae and the contact areas.

Rostratispora Bharadwaj and Venkatachala 1962 another lageniculate genus of megaspore is similar to *T. indianensis* in the type of ornamentation (verrucose) but has an apical prominence similar in form to *Lagenicula* and *Lagenoisporites.* Although lateral compressions of *Setispora* Butterworth and Spinner 1967 appear lageniculate, the height of laesurae is a result of capillate type ornamentation, and is not comparable with *T. indianensis*. *Triletes indianensis* Chaloner is therefore recombined to the genus

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EXPLANATION OF PLATE 85

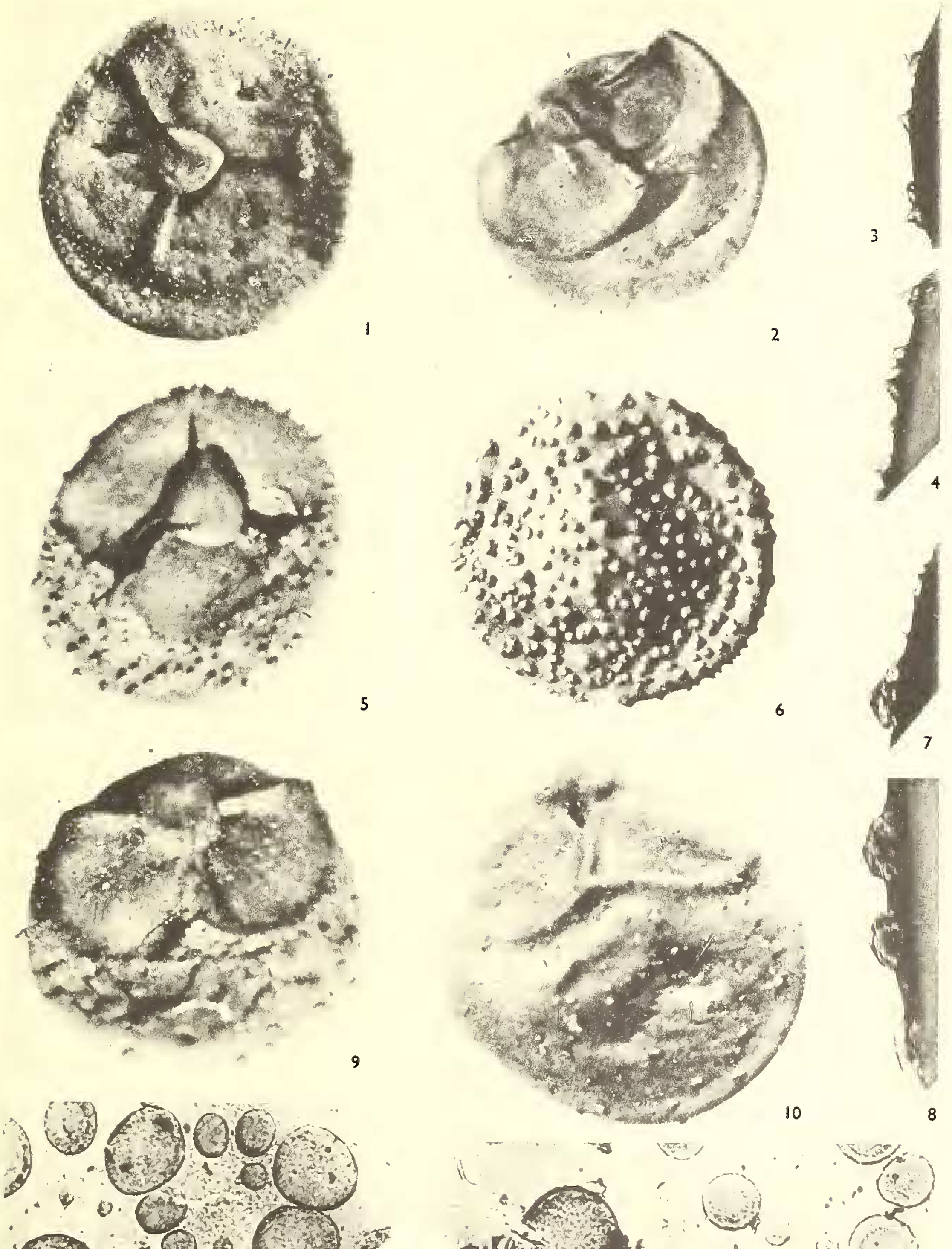
All specimens by reflected light, ×40, unless stated otherwise.

Figs. 1–4. *Setosisporites indianensis* (Chaloner 1954) comb. nov. 1, Proximal surface, polar compression, illustrating typical *Setisosporites* type apical prominence and large contact areas; slide D/6. 2. Lateral-oblique compression; slide D/6. 3, 4, Part of specimen illustrating ornamentation at spore margin, ×120, by transmitted light; slide D/14.

Figs. 5–7, 10–12. *Setosisporites splendidus* (Zerndt 1937) comb. nov. 5, Proximal surface, polar compression; slide D/5. 6, Distal surface, polar compression; slide D/5. 7, 10, Part of specimen illustrating ornament at spore margin, ×120, by transmitted light; slide D/5. 11, 12, Part of specimen illustrating types of ornament on distal surface, ×120, by transmitted light; slide D/15.

Fig. 8. *Setosisporites* sp. A, oblique compression; slide D/4.

Fig. 9. *Setosisporites* sp. B, lateral compression; slide D/3.



SPINNER, Scottish Viséan megaspores

Setosisporites as emended above in the characteristics of original shape of spore body, form of apical prominence and type of ornamentation.

Stratigraphic distribution. North America, Beaver Bend Limestone, Indiana, Low Chester Series, Mississippian (Chaloner 1954); Bethel Formation, Kentucky, Low Chester Series, Mississippian (Winslow 1959).

Setosisporites pseudoreticulatus sp. nov.

Plate 84, figs. 5–7

?1937 Type 13a, *Triletes tenuispinosus* var. *brevispinosa* Zerndt *pars*, p. 6, pl. 3, figs. 1, 2, 5–7.
?1957 *Triletes hirsutus* (Loose) var. *brevispinosa* Schopf, Wilson and Bentall *forma* I Dijkstra *pars*, p. 13, pl. 7 figs. 67–71.
?1959 *Triletes globosus* Arnold var. A Winslow, pl. 4, figs. 1–3.

Holotype. Plate 84, fig. 6.

Diagnosis. Trilete megaspores approximately circular to rounded triangular in outline varying 420–800 μ in maximum diameter. Apical prominence varies 60–120 μ in height, 90–150 μ in basal width, rounded at apex. Contact areas are ornamented with cones 4–6 μ high. Distal to the contact areas, baculate to pilate elements, 10–30 μ in length, up to 6 μ in basal diameter with small cone-like terminals, form an irregular reticulate pattern of ornamentation. These elements are densely placed in the region of curvaturae and may be partly fused to form a small flange-like structure 20–30 μ in width.

Description: Size and shape. Trilete megaspores, approximately circular to rounded triangular in outline, carrying between 420 and 800 μ in maximum diameter, mean 620 μ (based on 50 specimens in a hydrous medium). Polar, oblique and lateral compressions are all commonly found, there being no apparent preferred direction of compression. On lateral compressions the curved outline of the spore body is interrupted by a small 'neck-like' protuberance from the proximal pole. Originally, the spore body was of approximately spherical shape, the polar and equatorial axes being of similar dimensions.

Haptotypic features. Laesurae are straight to slightly sinuous in outline, approximately two thirds the radius of the spore body in length. The line of commissure may be ruptured, and is bounded by narrow (approximately 10 μ wide) tecta raised 20 μ high near the junction with the curvaturae. The height of the laesurae increases gradually 20–40 μ from the curvaturae towards the proximal pole, where there is a marked expansion forming an apical prominence. This structure varies 60–120 μ in height (measured in lateral compressions as projections from spore margin), 90–150 μ in basal diameter (measured perpendicular to height). The apex of the apical prominence is smoothly curved.

Contact areas are distinct occupying one-half to two-thirds of the proximal surface of the compressed spore, and ornamented with small cones, approximately 4 μ basal width, up to 6 μ high. On some specimens the contact areas have irregular areas of thickened exine, which tend to be arranged radially from the proximal pole. The curvaturae are represented by narrow thickenings on the exine.

Exine structure and sculpture. The spore wall excluding the contact areas, is covered by what are basically baculate to pilate type elements. These vary 10–30 μ in length, up to 6 μ in basal diameter, slightly swollen at the apex, where one or more small, pointed, cone-like projections may occur. The elements may be curved or straight-sided and are oftened joined at the bases. This feature, in addition to the elements being adpressed to the spore exine, gives the appearance of an irregular interrupted reticulum. On many specimens the elements are densely placed in the region of the curvaturae so as to form a small flange-like structure 20–30 μ wide.

Two layers of exine can easily be distinguished forming the spore wall. The outer layer appears infrapunctate, approximately 20 μ thick, measured in optical section, yellow-brown in colour. The inner layer, distinguished under transmitted light, is attached to the laesurae, thin and folded. In some specimens it is shrunken, but in others it is in close proximity to the thick outer layer.

Under reflected light, the exine is yellow-brown in colour, the apical prominence is not always clearly visible, and the sculptural elements appear more or less granular. The pseudoreticulate nature of the ornament is not clearly distinguishable.

Comparisons and remarks. This type of spore illustrates some of the difficulties that arise, when descriptions are given based on only one type of examination, i.e. reflected or transmitted light.

Under reflected light examination *S. pseudoreticulatus* is similar in shape, size, and ornamentation to *S. hirsutus* var. *brevispinosa* forma 1 (Zerndt) Potonié and Kremp 1955 as described by Zerndt (1937, p. 6) and Dijkstra (1957, p. 13). Zerndt noted that it was difficult to distinguish a regular form of the sculptural elements present on his specimens, but that he regarded the elements as small spines, up to 6 μ in length, 4 μ in basal width. He also reported much smaller elements on the contact areas of his material. On most specimens of *S. pseudoreticulatus* the elements are adpressed to the spore wall, and appear under reflected light as small projections of the size given by Zerndt. However, both Zerndt and Dijkstra emphasize the radial thickenings of the exine on the contact areas as being the characteristic feature of *S. hirsutus* var. *brevispinosa* forma 1. Although some specimens of *S. pseudoreticulatus* were found with thickenings on the contact areas, these were not common or as distinctive as suggested by Zerndt. It may be noted that Dijkstra (1957) using reflected light found *S. hirsutus* var. *brevispinosa* forma 1 to be common in the coals of the Limestone Coal Group of Scotland, slightly younger (E_1) in age than the horizon studied here. Thus, there is evidence which suggests that some of the material referred by earlier workers to *S. hirsutus* var. *brevispinosa* could be assigned to *S. pseudoreticulatus* and this is indicated in the synonmy given above. The major argument against such an assignment is the prominence of the radial thickenings on the contact areas, and the size of ornament.

Under transmitted light many more of the details of morphology of *S. pseudoreticulatus* are seen, and similarities can be seen with *S. globosus* (Arnold) Potonié and Kremp 1955 in shape and general morphology. However, *S. globosus* has a smaller size range (390–570 μ Arnold 1950, p. 80; 385–640 μ Winslow 1959, p. 42), and the sculptural elements are larger (35–50 μ length, up to 12 μ diameter; Arnold p. 80), straight-sided with terminal clefts. The sculptural elements are not joined to form a reticulate type pattern which characterises *S. pseudoreticulatus*, but are discrete and widely spaced.

Winslow (1959, pp. 43–5) described three varieties of *S. globosus*. Of these varieties, *S. pseudoreticulatus* is very similar to *S. globosus* var. A in length and height of laesurae, size of apical prominence, type and size of sculptural elements forming an irregular reticulate pattern (catenulate ornament of Winslow, p. 43). The size range of var. *A* is smaller (330–630 μ, mean 515 μ; Winslow, p. 43) than *S. pseudoreticulatus* (420–800 μ, mean 620 μ). Winslow (p. 43) also noted the similarities of var. A with *S. hirsutus* var. *brevispinosa* when compared under reflected light examination, but did not consider the two as being the same due to the absence of radial thickenings on the contact faces of variety A.

The differences in ornamentation between *S. globosus* and *S. pseudoreticulatus* (including Winslow's var. A, see synonymy) are considered here to warrant separation at specific level. No specimens with the type of ornamentation present on *S. globosus* were found associated with *S. pseudoreticulatus* during the present study.

Winslow's other two varieties of *S. globosus* can be distinguished from *S. pseudoreticulatus* by the larger size of the sculptural elements (15–57 μ, generally more than 35 μ, var. B) and the type of element (tubercles 5–26 μ length, 5–52 μ basal diameter, var. C).

S. pseudoreticulatus also resembles *S. reticulatus* Karczewska 1967 in size, shape, and ornament pattern. However, on *S. reticulatus* the outer layer of exine forms a uniform fused reticulum on the distal surface. Small projections 3–7 μ in length, are situated between the lumina of the reticulum.

S. pseudotenuispinosus Piérart 1958 and *S. pilatus* Spinner 1965 are similar in shape and size of the spore body to *S. pseudoreticulatus*, but these species have smaller, discrete, sculptural elements which do not form a reticulate type pattern.

Triletes catenulatus Winslow 1962 can be distinguished from *S. pseudoreticulatus* by the presence of highly developed laesurae (200 μ or more high).

In my opinion many of the specimens previously assigned to *S. hirsutus* var. *brevispinosa* forma 1 could be placed in *S. pseudoreticulatus*. However, rather than raise the varietal name to species rank, a new name is proposed for the following reasons. Zerndt (1937) recognised two forms (varieties 1, 2; Zerndt 1937, p. 7) within var. *brevispinosa*. These forms are markedly different in type and size of ornamentation (form 1, appendices up to 6 μ long; form 2, spines 39–96 μ wide at the base, decreasing to approximately 12 μ near the tip). However, Zerndt emphasized the folding, thickening on the contact areas as the common feature of both forms grouped within the named variety *brevispinosa*. Later Schopf, Wilson, and Bentall (1944, p. 26) in dealing with the problem of Zerndt's varieties within a variety regarded variety 1 of Zerndt as being var. *brevispinosa* and proposed a new varietal name *secundus* for variety 2 of Zerndt; whereas Dijkstra (1946, 1956) interpreted varieties 1, 2 of Zerndt as forms within var. *brevispinosa*. Due to the different interpretation of Zerndt's work, the emphasis on folding and thickening in his description of the variety, and the small size of the appendices on his form 1, a new name *pseudoreticulatus* is proposed for the species.

Botanical affinities. Unknown.

Stratigraphic distribution. ?Limestone Coal Group, Scotland, Namurian E_2 (Dijkstra 1957); Lower Carboniferous, Ireland (Chaloner 1966); ? Hardinsburg Formation, Kentucky, Wattersburg Formation, Illinois, Chester series, Low Mississippian (Winslow 1959).

Setosisporites splendidus (Zerndt) comb. nov.

Plate 85, figs. 5–8, 11–12

1937 Type 28; *Lagenicula splendida* Zerndt, p. 13–14, pl. 18, figs. 1, 2; pl. 19, figs. 1–3, 5; pl. 20, figs. 2, 3, 4.

1944 *Triletes splendida* (Zerndt) Schopf, Wilson, and Bentall, p. 25.
1946 *Triletes splendidus* (Zerndt) Dijkstra, p. 50, pl. 16, figs. 173–5.
1955 *Lagenicula splendida* Zerndt; Potonié and Kremp, p. 119.
1957 *Triletes splendidus* (Zerndt) S.W. et B.; Dijkstra, p. 14, pl. 8, figs. 85; pl. 9, figs. 86–8.
1959 *Triletes splendidus* (Zerndt) Schopf, Wilson, and Bentall; Winslow, p. 27, pl. 5, fig. 8.
?1962 *Lagenicula splendida* Zerndt; Ishchenko and Semenova, pp. 72–3, pl. 8.
?1962 *Lagenicula verrucosa* Ishchenko and Semenova, p. 74, pl. 9, fig. 3.

Description: Size and shape. Trilete megaspores more or less circular in equatorial outline. Lateral compressions are most commonly found which have a marked 'bottle-shaped' outline, the 'neck' being formed by an apical prominence at the proximal pole of spore. The difference between the polar and equatorial axes is not large, and on some lateral compressed specimens the polar axis is the smaller. Polar and oblique compressions also occur. Maximum diameter of the spore body including apical prominence on lateral compressions varies 935–1625 μ, mean 1225 μ based on 35 dry specimens. Originally, the spore body was more or less spherical in shape.

Hapotypic features. The characteristic feature here is the bluntly pyramidal apical prominence at the proximal pole, varying 200–300 μ in basal diameter, 150–270 μ high on lateral compressions, and may appear slightly constricted at the base. This structure is probably formed by an expansion of the exine of the immediate polar part of the contact areas, and in part by the laesurae. On some specimens, small ridge-like? continuations of the laesurae can be traced on to the prominence. In some specimens the laesurae are ruptured, but the ruptures have not been observed extending on to the prominence, whilst in other damaged specimens the prominence has been completely removed. Distal to the apical prominence, the laesurae form low ridges 250–400 μ long.

The contact areas occupy approximately three-quarters of the proximal half of the compressed spore. These are delimited from the remainder of the spore body by the smaller cone-like sculptural elements, generally less than 12 μ in diameter, but occasionally up to 30 μ on some specimens. Arcuate ridges representing the curvaturae are not well developed except at the junction with the laesurae i.e. curvaturae imperfectae.

Exine structure and sculpture. In the region of, and distal to the curvaturae the spore wall is ornamented with cones and granular type elements. These are most densely placed in the region of the curvaturae. Two groups of elements can be recognized based on size. The most prominent group consists of relatively large cones 30–75 μ in basal diameter (generally larger than 50 μ), 12–35 μ high, and often mammillate in form. Interspersed with these elements are smaller cone and granular type forms generally 20 μ or less in basal diameter, 5–15 μ high.

Broken specimens reveal a thin layer of exine, internal to the heavily ornamented layer which is approximately 50 μ thick.

Comparisons and remarks. The limits of this species are ill defined. Both Zerndt (1937, pp. 13–14, pls. 18–20) and Dijkstra (1946, p. 50, pl. 16, 1957, p. 14, pl. 8) allow considerable range in spore diameter (700–1700 μ; Dijkstra 1957) and in size of sculptural elements (16–97 μ diameter, Zerndt 1937; 10–150 μ diameter, Dijkstra 1957). At the same time both authors recognised other species e.g. *Lagenicula subtilinodulata* Nowak and Zerndt 1936, which could be placed within the limits they described for *L. splendida*. Chaloner (1954, p. 28) proposed *Triletes indianensis* for specimens having a distal ornamentation of elements of up to, but generally less than, 20 μ in length. These specimens could, on the basis of the limits given by Zerndt and Dijkstra, be assigned to *L. splendida*. Winslow (1959, pp. 26–7) recognizes *S. splendidus* (*Triletes splendida* of Winslow) as being larger in size of spore and ornamentation, than *L. subtilinodulata* and *Triletes indianensis*. Reference to the holotype is of no assistance for, as far as I am aware, neither Zerndt nor any other worker has designated a holotype for this species.

I do not think that any particular value should be placed on relatively small differences in the size of the spore body, but suggest that a useful character for distinguishing this species is the two types of sculptural element. This character is seen on Zerndt's specimens illustrating the species, and plate 18, fig. 2 is designated here as the lectotype of the species.

Triletes indianensis Chaloner 1954 differs from *S. splendidus* in the small size (generally less than 20 μ in basal diameter and height) of the elements forming the ornamentation on the spore wall.

Lagenicula agnina Zerndt 1937 can be distinguished from *S. splendidus* by the type of apical prominence (laesurae expanding along most of the length), small contact areas, and close verrucose ornament on the distal surface.

Lagenicula verrucosa Ishchenko and Semenova 1962 can according to its authors be distinguished from *S. splendidus* by its smaller size (1360×1325 μ) and 'barbate' sculpture. Judging from the drawings produced as illustrations of the two species, *L. verrucosa* appears more similar to the specimens described here than does *L. splendida sensu* Ishchenko and Semenova and this is indicated in the synonymy given above.

There is some reason to doubt the correctness of assigning this species to *Lagenicula* as described by Potonié and Kremp (1955, p. 118). In their diagnosis these authors maintain: 'a long polar axis, an apical prominence larger than the part of the contact areas not involved in its formation, and unornamented contact areas.' These features are not applicable to this species. The type and size of the apical prominence relative to the other haptotypic features is more typical of *Setosisporites* e.g. *S. praetextus* (Zerndt) Potonié and Kremp 1955. Consequently this species is assigned to *Setosisporites* as emended above.

Stratigraphic distribution. Europe: Poland, Dinantian-Namurian A (Zerndt 1937); U.S.S.R. Donetz Basin, ?Dinantian-Namurian, (Ishchenko and Semenova 1962); Ireland, Lower Carboniferous, (Dijkstra 1957, Chaloner 1966). North America: Degonia Formation, Chester Series, Illinois, Mississippian (Winslow 1959).

Setosisporites sp. A

Plate 85, fig. 9

Description. Trilete megaspores circular to oval in outline, approximately 1250 μ in maximum diameter (only two specimens found, 1310 and 1180 μ in maximum diameter). Apical prominence at proximal pole, blunt pyramidal shaped, 300 μ maximum diameter. Laesurae relatively low, 25–60 μ wide at junction with curvaturae. Contact areas approximately 650 μ in radius ornamented small cones 25 μ diameter. Spore wall distal to contact faces, ornamented with large cones 65–80 μ basal diameter, 60–70 μ high, smaller cones approximately 40 μ diameter in region of curvaturae.

Remarks. These megaspores closely resemble *Setosisporites splendidus* as described here, but have more typical conate ornamentation in which the elements are higher, approximately equal to basal diameter, and not mamillate in form as in *S. splendidus*. The elements are also not so densely placed on the contact areas or distal surface. *Lagenicula agnina* Zerndt 1937 has larger sculptural elements on the distal surface (97–225 μ width, 48–160 μ high; Zerndt 1937, p. 14). *L. subtilinodulata* Nowak and Zerndt 1936 is smaller in size of spore body and distal ornamentation, and the contact areas are laevigate.

Setosisporites sp. B

Plate 85, fig. 10

Description. Trilete megaspores 912–1500 μ maximum diameter, mean 1300 μ based on six dry specimens. Apical prominence is bluntly pyramidal, 150–225 μ high, 250–375 μ basal diameter. Laesurae, distal to apical prominence, are approximately 50–60 μ high and wide, best developed near the junction with the curvaturae. Contact areas occupy three-quarters proximal surface, smooth bounded by arcuate ridges 35–50 μ high, 50–80 μ wide, most pronounced at junction with the laesurae. Distal surface ornamented with irregularly scattered cones, 25–40 μ high, and wide, 60–300 μ apart.

Remarks. In type of apical prominence this species resembles *S. splendidus* and *S. indianensis*.

Genus ZONALESPORITES (Ibrahim) Potonié and Kremp emend. Spinner 1965

Type species. *Zonalesporites brasserti* (Stach and Zerndt) Potonié and Kremp 1956.

Zonalesporites fusinatus sp. nov.

Plate 86, figs. 1–4

?1957 *Triletes brasserti* Stach and Zerndt, type 20; Dijkstra *pars*, p. 13, pl. 7, figs. 73–6.

Holotype. Plate 86, fig. 1.

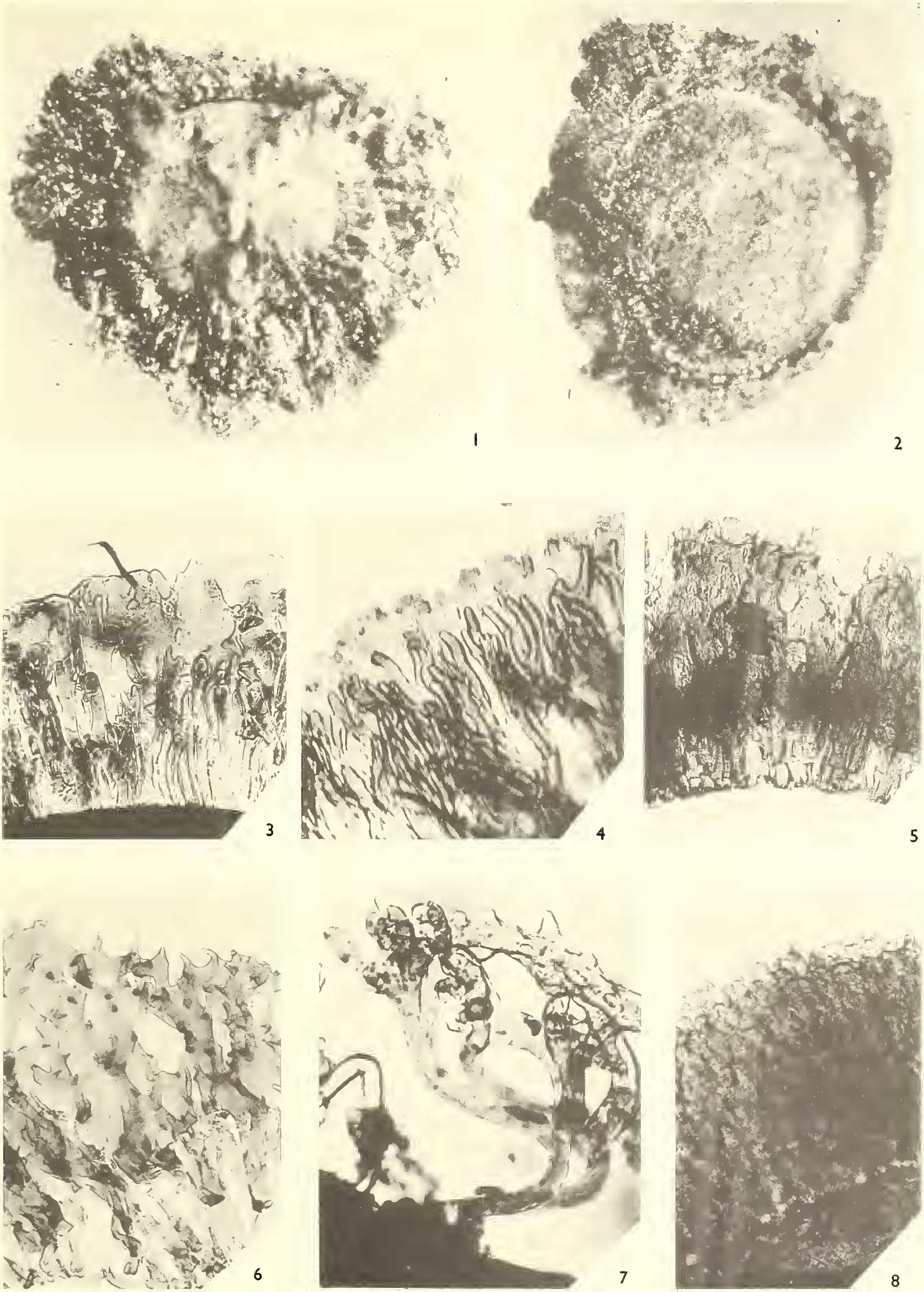
Diagnosis. Trilete megaspores composed of spore body with a subequatorial corona. Spore body varies 1300–2160 μ in maximum diameter. Corona varies 415–700 μ width, composed of a number of layers of baculate type elements, 10–30 μ width, with rounded tips. Elements are more fused distally to form a rim with some dissections and ornamented with small baculate processes. Margin of rim generally smooth, lacking ornamentation.

EXPLANATION OF PLATE 86

All specimens by transmitted light, ×40, unless stated otherwise.

Figs. 1–4. *Zonalesporites fusinatus* sp. nov. 1, Holotype, proximal surface, polar compression, by reflected light; slide D/1. 2, Distal surface, polar compression, by reflected light; slide D/2. 3, 4, Parts of corona, ×120; slide D/17.

Figs. 5–8. Parts of corona of *Zonalesporites* spp. for comparison with *Z. fusinatus*. 5, 8, *Z. brasserti* (Stach and Zerndt) Potonié and Kremp, ×120; slides WD/6, WD/8 (Westphalian B, South Wales Coalfield, Great Britain). 6, *Z. conacies* Butterworth and Spinner, ×100; slide V4/21 (Dinantian, S_2 age, Bernician Beds, Whitberry burn, Cumberland, England). 7, *Z.* cf. *ramosus* (Arnold) Spinner, ×250 (early Pennsylvanian, Williamston Spore coal, Michigan, U.S.A.; specimen lent by W. G. Chaloner, Botany Department, University College, London).



SPINNER, Scottish Viséan megaspores